Problem Set 2

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CAP 4763 Time Series Modelling and Forecasting

> All underlined portions are the corrections

> All uncited quotes are from the problem set

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Part A

1. Writethemodel $y_t = \alpha + \delta t + \rho y_{t-1} + \beta x_{t-1} + r$ in first differences.

- $\Delta y_t = \delta + \rho \Delta y_{t-1} + \beta \Delta x_{t-1} + \Delta r_t$

2. Suppose after first differencing a model is $\Delta y_t = \delta - \varphi - 2\varphi t + \rho \, \Delta \, y_{t-1} + \beta \, \Delta \, x_{t-1} + \Delta r_t$. What was it before the first difference was taken? (Hint: both t and t^2 are in it.)

- $y_t = \delta t + \varphi t^2 + \varphi t - \varphi + \rho y_{t-1} + \beta x_{t-1} + r_t$ <- WRONG
- $\Delta y_t = \delta - \phi + 2\phi t + \rho \Delta t_{t-1} + \beta \Delta x_{t-1} + \Delta r_t$ <- RIGHT

3. Suppose you are originally interested in the model $y_t = \alpha + \delta t + \rho y_{t-1} + \beta x_{t-1} + r_t$, where $r_t = \gamma r_{t-1} + \varepsilon_t$ and ε_t is an independent random disturbance. Write the dynamically complete model in first differences. Hint: first substitute to make the model dynamically complete, and then take the first difference.

- $y_t = \alpha + \delta t + \rho y_{t-1} + \beta x_{t-1} + \gamma r_{t-1} + \varepsilon_t$ <- WRONG
- $\Delta y_t = \delta + \rho \Delta y_{t-1} + \beta \Delta x_{t-1} + \gamma \Delta r_{t-1} + \Delta \varepsilon_t$ <- WRONG
- $\Delta y_t = \delta(1-\gamma) + (\rho + \gamma)\Delta y_{t-1} - \gamma\rho \Delta y_{t-2} + \beta \Delta x_{t-2} + \varepsilon_t - \varepsilon_{t-1}$<- RIGHT

Part B

3. Autocorrelation and Weak Dependence

1. Obtain the correlation of each variable with its one period lag.

Variable	**Correlation with Lag**
lnflnonfarm	.9981
lnfllf	.9994
lnusepr	.9821
lnflbp	.9477

(obs=875)	**corr ln_us_epr l1.ln_us_epr**
	L.
	ln_us~*r ln_us*~r
ln_us_epr	
-.	1.0000
L1.	0.9758 1.0000

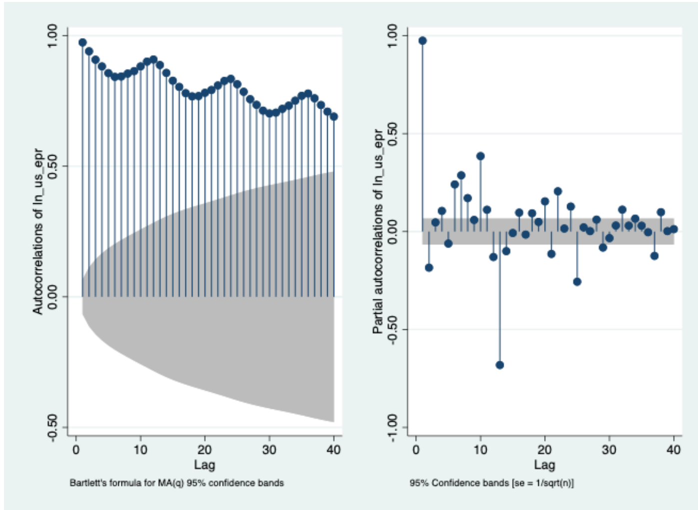
(obs=983)	corr ln_fl_nonfarm l1.ln_fl_nonfarm
	L.
	ln_fl~*m ln_fl*~m
ln_fl_nonf~m	
-.	1.0000
L1.	0.9999 1.0000

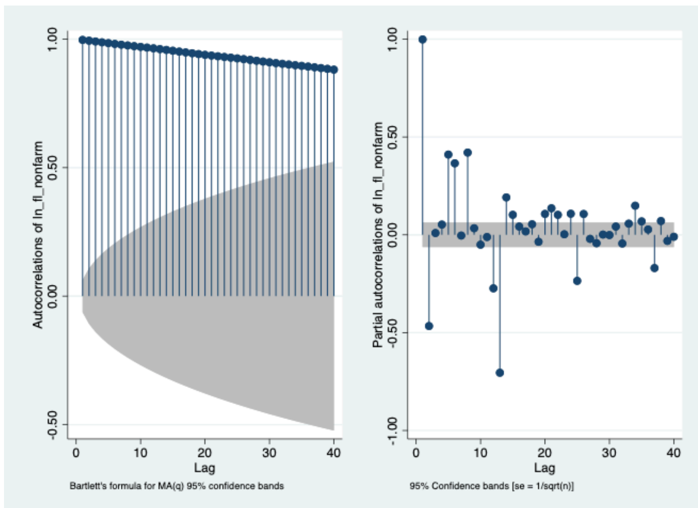
(obs=539)	corr ln_fl_lf l1.ln_fl_lf
	L.
	ln_fl_lf ln_fl_lf
ln_fl_lf	
-.	1.0000
L1.	0.9997 1.0000

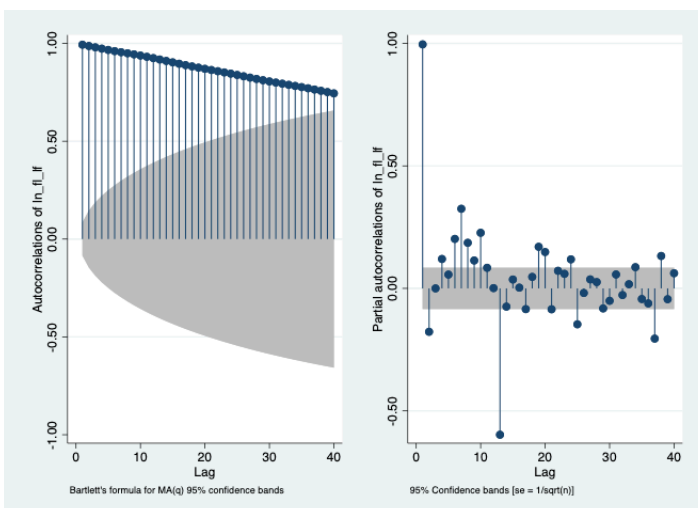
(obs=395)	corr ln_fl_bp l1.ln_fl_bp
	L.
	ln_fl_bp ln_fl_bp
ln_fl_bp	
-.	1.0000
L1.	0.9470 1.0000

- There appears to be very high correlation between the log form of each variable and its first lag. The highest is ln_fl_nonfarm with a correlation of .9999, followed by ln_fl_lf, ln_us_epr, and ln_fl_bp with .9997, .9758, and .9470 respectively.

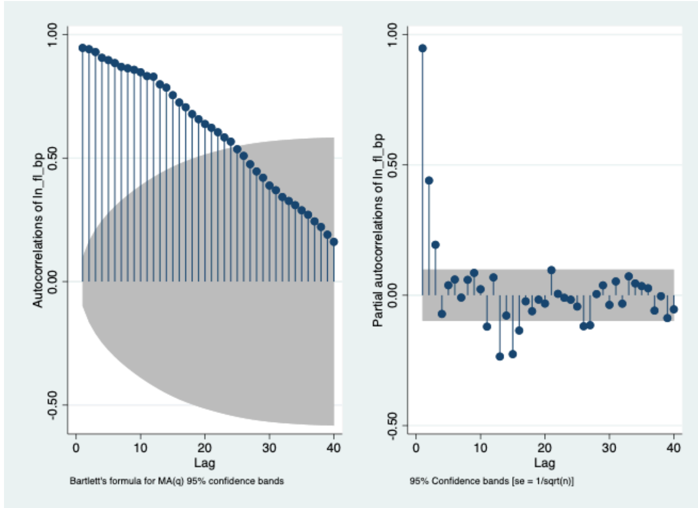
2. Obtain the autocorrelogram and partial autocorrelagram for each variable.







For the above three graphs, because all of the points are outside and above the cone, we can conclude that there is an autoregressive term in the data and should consult the partial autocorrelation graph. The PAC suggests that this is a higher order moving average.



For the last graph, the autocorrelation is not all outside of the confidence interval. When we look at the PAC we see that there are significant correlations in the first few terms followed by insignificant correlations in the rest. This suggests the order of the autoregressive term.

3. Conduct the Dickey-Fuller unit root rest for each variable.

Variable	**Dickey-Fuller p-value**
lnflnonfarm	.0328
lnfllf	.6285
lnusepr	.2246
lnflbp	.7774

```
. dfuller ln_us_epr, trend regress

Dickey-Fuller test for unit root                   Number of obs   =       875

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -4.020            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0082

------------------------------------------------------------------------------
D.ln_us_epr |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
  ln_us_epr |
        L1. |  -.0392314   .0097585    -4.02   0.000    -.0583843   -.0200784
            |
     _trend |   4.02e-06   1.84e-06     2.18   0.030     3.99e-07    7.63e-06
      _cons |   .1583652   .0392952     4.03   0.000     .0812411    .2354894
------------------------------------------------------------------------------
```

```
. dfuller ln_fl_nonfarm, trend regress

Dickey-Fuller test for unit root                   Number of obs   =       983

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.653            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9761

------------------------------------------------------------------------------
D.           |
ln_fl_nonfarm|      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
ln_fl_nonfarm|
         L1. |   -.001659   .0025399    -0.65   0.514    -.0066433    .0033253
             |
       _trend|   6.93e-07   8.56e-06     0.08   0.935    -.0000161    .0000175
        _cons|   .0159216   .0160282     0.99   0.321    -.0155318    .0473751
------------------------------------------------------------------------------

. dfuller ln_fl_lf, trend regress

Dickey-Fuller test for unit root                   Number of obs   =       539

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.724            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7400

------------------------------------------------------------------------------
  D.ln_fl_lf |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_fl_lf |
         L1. |  -.0076457   .0044337    -1.72   0.085    -.0163552    .0010639
             |
      _trend |   7.40e-06   8.61e-06     0.86   0.391    -9.52e-06    .0000243
       _cons |    .120517   .0676628     1.78   0.075    -.0123997    .2534337
------------------------------------------------------------------------------

. dfuller ln_fl_bp, trend regress

Dickey-Fuller test for unit root                   Number of obs   =       395

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.256            -3.984            -3.424            -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0738

------------------------------------------------------------------------------
  D.ln_fl_bp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_fl_bp |
         L1. |  -.0545463   .0167509    -3.26   0.001    -.0874792   -.0216134
             |
      _trend |  -.0000375   .0000734    -0.51   0.609    -.0001817    .0001067
       _cons |   .5091679   .1583766     3.21   0.001     .1977942    .8205417
------------------------------------------------------------------------------
```

For both Dickey-Fuller of the ln_us_epr, the p-value is extremely low at .0082 and so we accept the null hypothesis. For all others, we fail to reject the null hypothesis. Especially ln_fl_nonfarm and ln_fl_lf.

4. "Looking at the AC and PAC, all four show strong enough first order autoregressive relationships to merit differencing. We can reject the null of an I(1) process for the log of non-farm employment. But, the partial autocorrelation coefficient is so close to one that we should difference anyway. The AC and PAC for the log difference of non-farm employment are bwlow, illustrating the differences are clearly not I(1)."

4. ARDL Model and Breusch-Godfrey Test

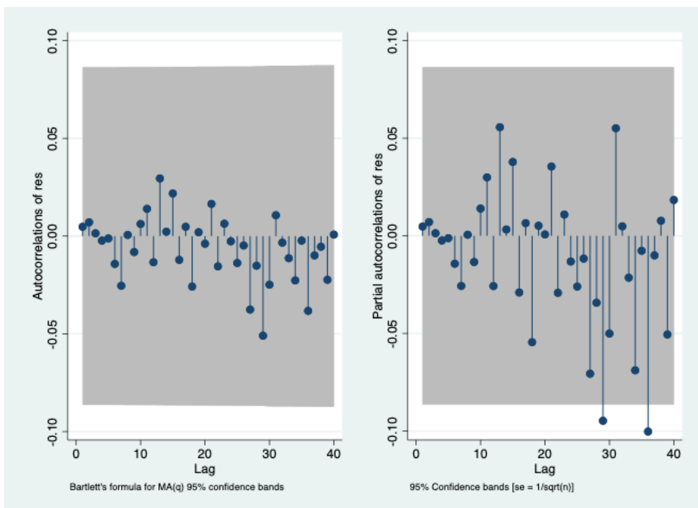
Given the results of the previous question, transform the data as needed and estimate a dynamically complete ARDL model for non-farm employment. Include at least one lag of the relevant dependent variable. How many additional lags of the dependent variable, and how many lags of which independent variables you include, are up to you. Looking back at what you did for Problem Set 1 might be informative, but don't be limited by it. Produce and interpret the AC and PAC for the residuals and the results of a Breusch-Godfrey test. In your write up, justify your specification and interpret the results.

.	**regress d.ln_fl_nonfarm l(1/48)d.ln_fl_nonfarm**	**l(12/24)d.ln_us_epr**	**l(1/18, 24)d.ln_fl_lf**	**date**
	Source SS df MS	Number of obs =	515	
	F(81, 433) =	15.48		
Model .050091055 81 .000618408	Prob > F =	0.0000		
Residual .01729335 433 .000039938	R-squared =	0.7434		
	Adj R-squared =	0.6954		
Total .067384405 514 .000131098	Root MSE =	.00632		
-------------	---------	---------	-----	-----
D.				
ln_fl_nonfarm	Coef.	Std. Err.	t	P>t
ln_fl_nonfarm				
LD.	-.1441103	.059346	-2.43	0.016
L2D.	-.1332106	.060728	-2.19	0.029
L3D.	.0520745	.060831	0.86	0.392
L4D.	.1139409	.0609067	1.87	0.062
L5D.	.066288	.0611891	1.08	0.279
L6D.	.1944856	.0614959	3.16	0.002
L7D.	.0759452	.0622902	1.22	0.223
L8D.	.0829208	.0631492	1.31	0.190
L9D.	.2532911	.0930772	2.72	0.007
L10D.	.1403499	.0960901	1.46	0.145
L11D.	.1893271	.0946093	2.00	0.046
L12D.	.4685154	.0957577	4.89	0.000

L13D.	.0758492	.1003991	0.76	0.450
L14D.	.0089228	.1008964	0.09	0.930
L15D.	.0490602	.1006788	0.49	0.626
L16D.	-.0187785	.1013922	-0.19	0.853
L17D.	.0547956	.1017669	0.54	0.591
L18D.	.0863921	.1011552	0.85	0.394
L19D.	-.25835	.1016689	-2.54	0.011
L20D.	-.1621826	.1009034	-1.61	0.109
L21D.	-.0839614	.1033319	-0.81	0.417
L22D.	-.1719582	.1017154	-1.69	0.092
L23D.	.0347504	.1011416	0.34	0.731
L24D.	.2927769	.0998811	2.93	0.004
L25D.	.1178616	.098203	1.20	0.231
L26D.	.0999885	.0980021	1.02	0.308
L27D.	-.1283723	.0980801	-1.31	0.191
L28D.	-.2031139	.0980964	-2.07	0.039
L29D.	-.2892074	.097907	-2.95	0.003
L30D.	-.5772115	.0991658	-5.82	0.000
L31D.	.6236058	.1020615	6.11	0.000
L32D.	.1870999	.1073141	1.74	0.082
L33D.	.1426809	.1091241	1.31	0.192
L34D.	.1068341	.1078243	0.99	0.322
L35D.	-.0794067	.1078368	-0.74	0.462
L36D.	.1327386	.1064489	1.25	0.213
L37D.	-.0639028	.099194	-0.64	0.520
L38D.	-.048562	.0984536	-0.49	0.622
L39D.	.0871388	.0975069	0.89	0.372
L40D.	-.1442082	.0974565	-1.48	0.140
L41D.	-.0032331	.0966638	-0.03	0.973
L42D.	.0938246	.0970599	0.97	0.334
L43D.	-.3559573	.0966539	-3.68	0.000
L44D.	-.0089124	.0978207	-0.09	0.927

L45D.	-.0882528	.0966085	-0.91	0.361
L46D.	.1086727	.091884	1.18	0.238
L47D.	.0313382	.091654	0.34	0.733
L48D.	.0609195	.091323	0.67	0.505
ln_us_epr				
L12D.	-.0155085	.1744885	-0.09	0.929
L13D.	-.3056076	.153451	-1.99	0.047
L14D.	-.5608006	.1545155	-3.63	0.000
L15D.	-.3645519	.1519838	-2.40	0.017
L16D.	.0029936	.1580302	0.02	0.985
L17D.	.0422232	.1559561	0.27	0.787
L18D.	.3199335	.1565006	2.04	0.042
L19D.	-.07463	.0988972	-0.75	0.451
L20D.	.0625226	.0999685	0.63	0.532
L21D.	-.0436852	.1002131	-0.44	0.663
L22D.	.2231831	.0985078	2.27	0.024
L23D.	-.0081188	.0960409	-0.08	0.933
L24D.	-.2688582	.1616447	-1.66	0.097
ln_fl_lf				
LD.	.1762398	.0704433	2.50	0.013
L2D.	-.1356975	.0715783	-1.90	0.059
L3D.	-.1659446	.0715828	-2.32	0.021
L4D.	-.0977864	.0709175	-1.38	0.169
L5D.	-.1364495	.0722069	-1.89	0.059
L6D.	-.2270642	.0723796	-3.14	0.002
L7D.	-.1332104	.0724525	-1.84	0.067
L8D.	-.2396185	.0727056	-3.30	0.001
L9D.	-.1256755	.079465	-1.58	0.114
L10D.	-.180737	.0797732	-2.27	0.024
L11D.	-.005726	.0808095	-0.07	0.944

L12D.	.0558537	.1334055	0.42	0.676
L13D.	.0173463	.1262683	0.14	0.891
L14D.	.2969825	.1275491	2.33	0.020
L15D.	.125207	.1266497	0.99	0.323
L16D.	-.0665773	.1288379	-0.52	0.606
L17D.	-.1292395	.1273895	-1.01	0.311
L18D.	-.2883037	.1278108	-2.26	0.025
L24D.	.2278015	.1255369	1.81	0.070
date	-8.65e-06	3.19e-06	-2.72	0.007
_cons	.0058495	.0022338	2.62	0.009



I don't think there's any correlation because almost everything is inside the interval.

. estat bgodfrey, lag(1/48)	
Breusch-Godfrey LM test for	autocorrelation

lags(p)	chi2	df	Prob > chi2
1	0.617	1	0.4321
2	1.630	2	0.4427

3	1.639	3	0.6506
4	1.665	4	0.7970
5	1.730	5	0.8850
6	2.757	6	0.8387
7	8.252	7	0.3109
8	8.536	8	0.3830
9	8.707	9	0.4648
10	8.803	10	0.5509
11	9.015	11	0.6205
12	10.913	12	0.5364
13	12.697	13	0.4715
14	12.775	14	0.5443
15	14.075	15	0.5198
16	15.212	16	0.5091
17	15.284	17	0.5751
18	18.315	18	0.4351
19	18.317	19	0.5014
20	19.893	20	0.4647
21	19.920	21	0.5263
22	20.203	22	0.5704
23	20.218	23	0.6287
24	20.362	24	0.6760
25	21.112	25	0.6864
26	21.381	26	0.7221
27	23.290	27	0.6693
28	24.359	28	0.6624
29	25.322	29	0.6615

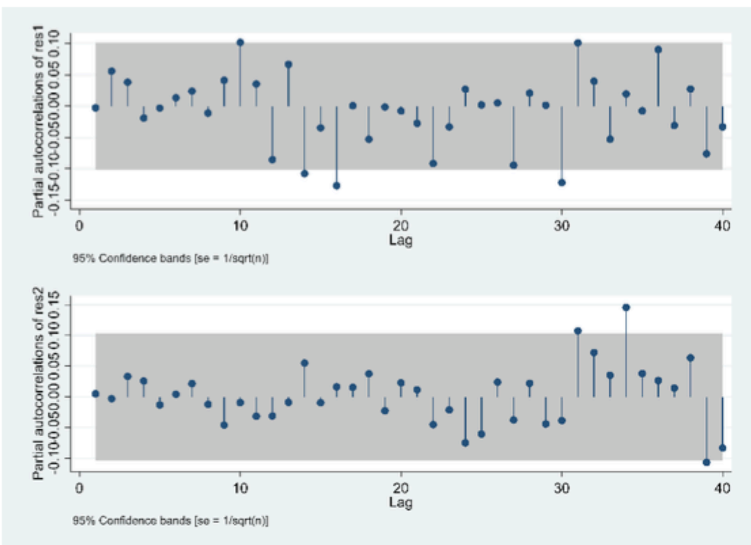
30	27.716	30	0.5855
31	28.706	31	0.5846
32	28.728	32	0.6330
33	29.272	33	0.6533
34	30.894	34	0.6207
35	30.897	35	0.6666
36	33.834	36	0.5720
37	35.071	37	0.5597
38	35.519	38	0.5847
39	38.229	39	0.5049
40	38.448	40	0.5402
41	38.548	41	0.5801
42	39.001	42	0.6034
43	39.107	43	0.6408
44	39.122	44	0.6804
45	39.431	45	0.7061
46	39.812	46	0.7278
47	40.011	47	0.7550
48	40.617	48	0.7664
H0: no serial correlation			

4) Given the results of the previous question, transform the data as needed and estimate a dynamically complete ARDL model for non-farm employment. Include at least one lag of the relevant dependent variable. How many additional lags of the dependent variable, and how many lags of which independent variables you include, are up to you. Looking back at what you did for Problem Set 1 might be informative, but don't be limited by it. Produce and interpret the AC and PAC for the residuals and the results of a Breusch-Godfrey test. In your write up, justify your specification and interpret the results.

I estimated two models, one with all lags back 12 months and one going back 24 months. Breush-Godfrey test results are in the table below. In the first case, the null of no serial correlation is rejected. For the second, the null can't be rejected at 24 lags, but it neither is it convincingly rejected (p=0.16). However, examining the PACs for the residuals in the figure below gives a bit more confidence in the second model. It also suggests some lags from year 3 and 4 may be worth including.

Breush-Godfrey tests for question 4

	$p >$ chi	
Lags	Model 1	Model 2
1	0.8812	0.4861
2	0.0332	0.778
3	0.0074	0.0585
4	0.0129	0.0386
5	0.0266	0.0709
6	0.0475	0.0774
7	0.0787	0.1049
8	0.0453	0.1426
9	0.068	0.1042
10	0.0467	0.1464
11	0.0688	0.1728
12	0.005	0.2121
13	0.0035	0.2321
14	0.0047	0.1206
15	0.0064	0.1304
16	0.0007	0.1483
17	0.0012	0.1816
18	0.0019	0.2039
19	0.0028	0.2119
20	0.0037	0.2138
21	0.0056	0.255
22	0.006	0.2065
23	0.0066	0.2485
24	0.0079	0.1618



A more parsimonious model, possibly with selected lags out further, might be a good idea. However, with some careful thought and exploration, I still have not come up with one that passed a Breusch-Godfrey test. Perhaps you did… Really, we will need more model selection tools to help us choose if we want to forecast. If we need to estimate parameters, we need to choose the appropriate model for the purpose, even if not dynamically complete, and then use appropriately adjusted standard errors. That is the point of the next problem.

5. Dynamically Complete Models and Newey-West Standard Errors

```
. reg d.ln_fl_nonfarm l(0/4)d.ln_fl_bp if tin(1948m1,2020m1)

      Source |       SS           df       MS      Number of obs   =       380
-------------+----------------------------------   F(5, 374)       =      2.97
       Model |   .00146591         5  .000293182   Prob > F        =    0.0122
    Residual |  .036972226       374  .000098856   R-squared       =    0.0381
-------------+----------------------------------   Adj R-squared   =    0.0253
       Total |  .038438136       379   .00010142   Root MSE        =    .00994

------------------------------------------------------------------------------
D.           |
ln_fl_nonf~m |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_fl_bp |
         D1. |  -.0043445   .0035864    -1.21   0.227    -.0113965    .0027075
         LD. |  -.0115113   .0040594    -2.84   0.005    -.0194935   -.0035291
        L2D. |   .0019871   .0041056     0.48   0.629    -.0060858      .01006
        L3D. |  -.0011778   .0040768    -0.29   0.773    -.0091941    .0068385
        L4D. |  -.0028262   .0036121    -0.78   0.434    -.0099287    .0042763
             |
       _cons |   .0015358   .0005101     3.01   0.003     .0005328    .0025387
------------------------------------------------------------------------------

. newey d.ln_fl_nonfarm l(0/4)d.ln_fl_bp if tin(1948m1,2020m1), lag(4)

Regression with Newey-West standard errors      Number of obs     =        380
maximum lag: 4                                  F(  5,       374) =       4.01
                                                Prob > F          =     0.0015

------------------------------------------------------------------------------
D.           |             Newey-West
ln_fl_nonf~m |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_fl_bp |
         D1. |  -.0043445    .003622    -1.20   0.231    -.0114665    .0027776
         LD. |  -.0115113   .0036606    -3.14   0.002    -.0187093   -.0043133
        L2D. |   .0019871   .0043475     0.46   0.648    -.0065616    .0105358
        L3D. |  -.0011778    .004813    -0.24   0.807    -.0106416     .008286
        L4D. |  -.0028262    .003664    -0.77   0.441    -.0100308    .0043783
             |
       _cons |   .0015358   .0004154     3.70   0.000     .0007189    .0023526
------------------------------------------------------------------------------
```

if fuller high, can't reject

5) Suppose you are interested in the relationship between the first difference in non-farm employment and the lags 0 to 4 of the differences of Florida building permits, controlling for seasonal impacts, but not controlling for any other variables or lags, including lags of employment. That is, you explicitly do not want to a dynamically complete model. (Don't worry about why, for this purpose.) Estimate the model both with and without Newey-West standard errors and discuss the difference that makes.

The results of interest are in the table at right. Note that the Newey-West standard errors are larger for the first three coefficients and smaller for the last. The regular standard errors are misleading regarding the precision of the estimates.

Models for question 5

Std Err	Regular	Newey-West
D.lnflbp	0.00820^{***}	0.00820^{**}
	(0.00203)	(0.00250)
LD.lnflbp	0.00793^{***}	0.00793^{**}
	(0.00236)	(0.00294)
L2D.lnflbp	0.00627^{*}	0.00627
	(0.00244)	(0.00348)
L3D.lnflbp	0.00730^{**}	0.00730^{*}
	(0.00237)	(0.00300)
L4D.lnflbp	0.00430^{*}	0.00430^{*}
	(0.00204)	(0.00199)
N	379	379
R^2	0.764	

Standard errors in parentheses
$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$
Constant, trend, and month coefficients omitted for space

Appendix A

```
clear
set more off

cd "/Users/guslipkin/Documents/Spring2020/CAP 4763 ~ Time Series/Problem Sets/Problem Set 2"

*2a
*Done

*2b Load the data
import delimited "Assignment_1_Monthly.txt"

rename lnu02300000 us_epr
rename flnan fl_nonfarm
rename fllfn fl_lf
rename flbppriv fl_bp
rename date datestring
```

```
*2c Turn on a log file
log using "Problem Set 1", replace

*2d Generate a monthly date variable (make its display format monthly time, %tm)
gen datec=date(datestring, "YMD")
gen date=mofd(datec)
format date %tm

*2e tsset your data
tsset date

*2f
gen ln_us_epr=log(us_epr)
gen ln_fl_nonfarm=log(fl_nonfarm)
gen ln_fl_lf=log(fl_lf)
gen ln_fl_bp=log(fl_bp)

*3a
corr ln_us_epr l1.ln_us_epr
corr ln_fl_nonfarm l1.ln_fl_nonfarm
corr ln_fl_lf l1.ln_fl_lf
corr ln_fl_bp l1.ln_fl_bp

*3b
ac ln_us_epr, saving(ac_ln_us_epr.gph, replace)
pac ln_us_epr, saving(pac_ln_us_epr.gph, replace)
graph combine ac_ln_us_epr.gph pac_ln_us_epr.gph, saving(combo_ln_us_epr.gph, replace)

ac ln_fl_nonfarm, saving(ac_ln_fl_nonfarm.gph, replace)
pac ln_fl_nonfarm, saving(pac_ln_fl_nonfarm.gph, replace)
graph combine ac_ln_fl_nonfarm.gph pac_ln_fl_nonfarm.gph, saving(combo_ln_fl_nonfarm.gph, replace)

ac ln_fl_lf, saving(ac_ln_fl_lf.gph, replace)
pac ln_fl_lf, saving(pac_ln_fl_lf.gph, replace)
graph combine ac_ln_fl_lf.gph pac_ln_fl_lf.gph, saving(combo_ln_fl_lf.gph, replace)

ac ln_fl_bp, saving(ac_ln_fl_bp.gph, replace)
pac ln_fl_bp, saving(pac_ln_fl_bp.gph, replace)
graph combine ac_ln_fl_bp.gph pac_ln_fl_bp.gph, saving(combo_ln_fl_bp.gph, replace)

*3c
dfuller ln_us_epr, trend regress
dfuller ln_fl_nonfarm, trend regress
dfuller ln_fl_lf, trend regress
dfuller ln_fl_bp, trend regress

*4
```

```
regress d.ln_fl_nonfarm l(1/48)d.ln_fl_nonfarm l(12/24)d.ln_us_epr l(1/18,
24)d.ln_fl_lf date
predict res, residual
ac res, saving(p4_ac.gph, replace)
pac res, saving(p4_pac.gph, replace)
graph combine p4_ac.gph p4_pac.gph, saving(p4_combo.gph, replace)
estat bgodfrey, lag(1/48)

*5
reg d.ln_fl_nonfarm l(0/4)d.ln_fl_bp if tin(1948m1,2020m1)
newey d.ln_fl_nonfarm l(0/4)d.ln_fl_bp if tin(1948m1,2020m1), lag(4)

log close
```

Appendix B

```
      name:  <unnamed>
       log:  /Users/guslipkin/Documents/Spring2020/CAP 4763 ~ Time Series/Problem S
> ets/Problem Set 2/Problem Set 1.smcl
  log type:  smcl
 opened on:  26 Feb 2021, 18:08:56

.
. *2d Generate a monthly date variable (make its display format monthly time, %tm)
. gen datec=date(datestring, "YMD")

. gen date=mofd(datec)

. format date %tm

.
. *2e tsset your data
. tsset date
        time variable:  date, 1939m1 to 2020m12
                delta:  1 month

.
. *2f
. gen ln_us_epr=log(us_epr)
(108 missing values generated)

. gen ln_fl_nonfarm=log(fl_nonfarm)

. gen ln_fl_lf=log(fl_lf)
(444 missing values generated)

. gen ln_fl_bp=log(fl_bp)
(588 missing values generated)

.
. *3a
. corr ln_us_epr l1.ln_us_epr
(obs=875)

             |                L.
             | ln_us_~r ln_us_~r
-------------+------------------
   ln_us_epr |
         --. |   1.0000
         L1. |   0.9758   1.0000


. corr ln_fl_nonfarm l1.ln_fl_nonfarm
(obs=983)

             |                L.
             | ln_fl_~m ln_fl_~m
-------------+------------------
ln_fl_nonf~m |
         --. |   1.0000
         L1. |   0.9999   1.0000


. corr ln_fl_lf l1.ln_fl_lf
(obs=539)

             |                L.
             | ln_fl_lf ln_fl_lf
-------------+------------------
    ln_fl_lf |
         --. |   1.0000
```

```
         --.  |   1.0000
         L1.  |   0.9997   1.0000


. corr ln_fl_bp l1.ln_fl_bp
(obs=395)

             |                L.
             | ln_fl_bp ln_fl_bp
-------------+------------------
    ln_fl_bp |
         --. |   1.0000
         L1. |   0.9470   1.0000


.
. *3b
. ac ln_us_epr, saving(ac_ln_us_epr.gph, replace)
(file ac_ln_us_epr.gph saved)

. pac ln_us_epr, saving(pac_ln_us_epr.gph, replace)
(file pac_ln_us_epr.gph saved)

. graph combine ac_ln_us_epr.gph pac_ln_us_epr.gph, saving(combo_ln_us_epr.gph, rep
> lace)
(file combo_ln_us_epr.gph saved)

.
. ac ln_fl_nonfarm, saving(ac_ln_fl_nonfarm.gph, replace)
(file ac_ln_fl_nonfarm.gph saved)

. pac ln_fl_nonfarm, saving(pac_ln_fl_nonfarm.gph, replace)
(file pac_ln_fl_nonfarm.gph saved)

. graph combine ac_ln_fl_nonfarm.gph pac_ln_fl_nonfarm.gph, saving(combo_ln_fl_nonf
> arm.gph, replace)
(file combo_ln_fl_nonfarm.gph saved)

.
. ac ln_fl_lf, saving(ac_ln_fl_lf.gph, replace)
(file ac_ln_fl_lf.gph saved)

. pac ln_fl_lf, saving(pac_ln_fl_lf.gph, replace)
(file pac_ln_fl_lf.gph saved)

. graph combine ac_ln_fl_lf.gph pac_ln_fl_lf.gph, saving(combo_ln_fl_lf.gph, replac
> e)
(file combo_ln_fl_lf.gph saved)

.
. ac ln_fl_bp, saving(ac_ln_fl_bp.gph, replace)
(file ac_ln_fl_bp.gph saved)

. pac ln_fl_bp, saving(pac_ln_fl_bp.gph, replace)
(file pac_ln_fl_bp.gph saved)

. graph combine ac_ln_fl_bp.gph pac_ln_fl_bp.gph, saving(combo_ln_fl_bp.gph, replac
> e)
(file combo_ln_fl_bp.gph saved)

.
. *3c
. dfuller ln_us_epr, trend regress

Dickey-Fuller test for unit root                   Number of obs   =       875

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -4.020            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0082

------------------------------------------------------------------------------
D.ln_us_epr  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   ln_us_epr |
         L1. |  -.0392314   .0097585    -4.02   0.000    -.0583843   -.0200784
             |
      _trend |   4.02e-06   1.84e-06     2.18   0.030     3.99e-07    7.63e-06
       _cons |   .1583652   .0392952     4.03   0.000     .0812411    .2354894
------------------------------------------------------------------------------

. dfuller ln_fl_nonfarm, trend regress

Dickey-Fuller test for unit root                   Number of obs   =       983

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.653            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9761
```

D. ln_fl_nonfarm	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fl_nonfarm						
L1.	-.001659	.0025399	-0.65	0.514	-.0066433	.0033253
_trend	6.93e-07	8.56e-06	0.08	0.935	-.0000161	.0000175
_cons	.0159216	.0160282	0.99	0.321	-.0155318	.0473751

```
. dfuller ln_fl_lf, trend regress
```

Dickey-Fuller test for unit root   Number of obs   =   539

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-1.724	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.7400

D.ln_fl_lf	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fl_lf						
L1.	-.0076457	.0044337	-1.72	0.085	-.0163552	.0010639
_trend	7.40e-06	8.61e-06	0.86	0.391	-9.52e-06	.0000243
_cons	.120517	.0676628	1.78	0.075	-.0123997	.2534337

```
. dfuller ln_fl_bp, trend regress
```

Dickey-Fuller test for unit root   Number of obs   =   395

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.256	-3.984	-3.424	-3.130

MacKinnon approximate p-value for Z(t) = 0.0738

D.ln_fl_bp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fl_bp						
L1.	-.0545463	.0167509	-3.26	0.001	-.0874792	-.0216134
_trend	-.0000375	.0000734	-0.51	0.609	-.0001817	.0001067
_cons	.5091679	.1583766	3.21	0.001	.1977942	.8205417

```
.
. *4
. regress d.ln_fl_nonfarm l(1/48)d.ln_fl_nonfarm l(12/24)d.ln_us_epr l(1/18, 24)d.l
> n_fl_lf date
```

Source	SS	df	MS		
				Number of obs =	515
				F(81, 433) =	15.48
Model	.050091055	81	.000618408	Prob > F =	0.0000
Residual	.01729335	433	.000039938	R-squared =	0.7434
				Adj R-squared =	0.6954
Total	.067384405	514	.000131098	Root MSE =	.00632

D. ln_fl_nonfarm	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_fl_nonfarm						
LD.	-.1441103	.059346	-2.43	0.016	-.2607523	-.0274683
L2D.	-.1332106	.060728	-2.19	0.029	-.2525689	-.0138524
L3D.	.0520745	.060831	0.86	0.392	-.0674863	.1716354
L4D.	.1139409	.0609067	1.87	0.062	-.0057687	.2336504
L5D.	.066288	.0611891	1.08	0.279	-.0539766	.1865526
L6D.	.1944856	.0614959	3.16	0.002	.073618	.3153532
L7D.	.0759452	.0622902	1.22	0.223	-.0464836	.1983741
L8D.	.0829208	.0631492	1.31	0.190	-.0411963	.207038
L9D.	.2532911	.0930772	2.72	0.007	.0703519	.4362303
L10D.	.1403499	.0960901	1.46	0.145	-.0485112	.329211
L11D.	.1893271	.0946093	2.00	0.046	.0033766	.3752776
L12D.	.4685154	.0957577	4.89	0.000	.2803077	.6567232
L13D.	.0758492	.1003991	0.76	0.450	-.1214811	.2731795
L14D.	.0089228	.1008964	0.09	0.930	-.1893847	.2072303
L15D.	.0490602	.1006788	0.49	0.626	-.1488197	.24694
L16D.	-.0187785	.1013922	-0.19	0.853	-.2180605	.1805035
L17D.	.0547956	.1017669	0.54	0.591	-.1452228	.2548141
L18D.	.0863921	.1011552	0.85	0.394	-.1124241	.2852084
L19D.	-.25835	.1016689	-2.54	0.011	-.4581759	-.0585241
L20D.	-.1621826	.1009034	-1.61	0.109	-.360504	.0361389
L21D.	-.0839614	.1033319	-0.81	0.417	-.2870559	.1191331
L22D.	-.1719582	.1017154	-1.69	0.092	-.3718755	.0279592

L23D.	.0347504	.1011416	0.34	0.731	-.1640391	.2335399
L24D.	.2927769	.0998811	2.93	0.004	.0964647	.489089
L25D.	.1178616	.098203	1.20	0.231	-.0751523	.3108754
L26D.	.0999885	.0980021	1.02	0.308	-.0926304	.2926074
L27D.	-.1283723	.0980801	-1.31	0.191	-.3211445	.0644
L28D.	-.2031139	.0980964	-2.07	0.039	-.3959182	-.0103096
L29D.	-.2892074	.097907	-2.95	0.003	-.4816395	-.0967753
L30D.	-.5772115	.0991658	-5.82	0.000	-.7721176	-.3823054
L31D.	.6236058	.1020615	6.11	0.000	.4230083	.8242034
L32D.	.1870999	.1073141	1.74	0.082	-.0238215	.3980212
L33D.	.1426809	.1091241	1.31	0.192	-.0717978	.3571596
L34D.	.1068341	.1078243	0.99	0.322	-.1050899	.3187581
L35D.	-.0794067	.1078368	-0.74	0.462	-.2913554	.1325421
L36D.	.1327386	.1064489	1.25	0.213	-.0764823	.3419594
L37D.	-.0639028	.099194	-0.64	0.520	-.2588645	.1310589
L38D.	-.048562	.0984536	-0.49	0.622	-.2420684	.1449445
L39D.	.0871388	.0975069	0.89	0.372	-.104507	.2787845
L40D.	-.1442082	.0974565	-1.48	0.140	-.3357548	.0473384
L41D.	-.0032331	.0966638	-0.03	0.973	-.1932218	.1867555
L42D.	.0938246	.0970599	0.97	0.334	-.0969425	.2845917
L43D.	-.3559573	.0966539	-3.68	0.000	-.5459264	-.1659882
L44D.	-.0089124	.0978207	-0.09	0.927	-.2011749	.1833501
L45D.	-.0882528	.0966085	-0.91	0.361	-.2781327	.1016272
L46D.	.1086727	.091884	1.18	0.238	-.0719214	.2892668
L47D.	.0313382	.091654	0.34	0.733	-.1488038	.2114803
L48D.	.0609195	.091323	0.67	0.505	-.118572	.240411
ln_us_epr						
L12D.	-.0155085	.1744885	-0.09	0.929	-.3584584	.3274413
L13D.	-.3056076	.153451	-1.99	0.047	-.607209	-.0040062
L14D.	-.5608006	.1545155	-3.63	0.000	-.8644942	-.257107
L15D.	-.3645519	.1519838	-2.40	0.017	-.6632696	-.0658341
L16D.	.0029936	.1580302	0.02	0.985	-.3076081	.3135954
L17D.	.0422232	.1559561	0.27	0.787	-.264302	.3487483
L18D.	.3199335	.1565006	2.04	0.042	.0123381	.6275288
L19D.	-.07463	.0988972	-0.75	0.451	-.2690083	.1197484
L20D.	.0625226	.0999685	0.63	0.532	-.1339614	.2590065
L21D.	-.0436852	.1002131	-0.44	0.663	-.2406498	.1532795
L22D.	.2231831	.0985078	2.27	0.024	.0295703	.416796
L23D.	-.0081188	.0960409	-0.08	0.933	-.1968832	.1806456
L24D.	-.2688582	.1616447	-1.66	0.097	-.5865639	.0488476
ln_fl_lf						
LD.	.1762398	.0704433	2.50	0.013	.0377865	.3146932
L2D.	-.1356975	.0715783	-1.90	0.059	-.2763815	.0049866
L3D.	-.1659446	.0715828	-2.32	0.021	-.3066375	-.0252517
L4D.	-.0977864	.0709175	-1.38	0.169	-.2371718	.041599
L5D.	-.1364495	.0722069	-1.89	0.059	-.278369	.00547
L6D.	-.2270642	.0723796	-3.14	0.002	-.3693234	-.0848051
L7D.	-.1332104	.0724525	-1.84	0.067	-.2756127	.0091919
L8D.	-.2396185	.0727056	-3.30	0.001	-.3825182	-.0967187
L9D.	-.1256755	.079465	-1.58	0.114	-.2818605	.0305095
L10D.	-.180737	.0797732	-2.27	0.024	-.3375278	-.0239463
L11D.	-.005726	.0808095	-0.07	0.944	-.1645537	.1531017
L12D.	.0558537	.1334055	0.42	0.676	-.2063492	.3180565
L13D.	.0173463	.1262683	0.14	0.891	-.2308286	.2655213
L14D.	.2969825	.1275491	2.33	0.020	.0462901	.547675
L15D.	.125207	.1266497	0.99	0.323	-.1237177	.3741316
L16D.	-.0665773	.1288379	-0.52	0.606	-.3198027	.186648
L17D.	-.1292395	.1273895	-1.01	0.311	-.3796182	.1211391
L18D.	-.2883037	.1278108	-2.26	0.025	-.5395104	-.037097
L24D.	.2278015	.1255369	1.81	0.070	-.018936	.4745389
date	-8.65e-06	3.19e-06	-2.72	0.007	-.0000149	-2.39e-06
_cons	.0058495	.0022338	2.62	0.009	.0014592	.0102399

```
. predict res, residual
(469 missing values generated)

. ac res, saving(p4_ac.gph, replace)
(file p4_ac.gph saved)

. pac res, saving(p4_pac.gph, replace)
(file p4_pac.gph saved)

. graph combine p4_ac.gph p4_pac.gph, saving(p4_combo.gph, replace)
(file p4_combo.gph saved)

. estat bgodfrey, lag(1/48)
```

Breusch-Godfrey LM test for autocorrelation

lags(*p*)	chi2	df	Prob > chi2
1	0.617	1	0.4321
2	1.630	2	0.4427
3	1.639	3	0.6506
4	1.665	4	0.7970
5	1.730	5	0.8850
6	2.757	6	0.8387
7	8.252	7	0.3109
8	8.536	8	0.3830
9	8.707	9	0.4648
10	8.803	10	0.5509

```
      11      |        9.015           11                 0.6205
      12      |       10.913           12                 0.5364
      13      |       12.697           13                 0.4715
      14      |       12.775           14                 0.5443
      15      |       14.075           15                 0.5198
      16      |       15.212           16                 0.5091
      17      |       15.284           17                 0.5751
      18      |       18.315           18                 0.4351
      19      |       18.317           19                 0.5014
      20      |       19.893           20                 0.4647
      21      |       19.920           21                 0.5263
      22      |       20.203           22                 0.5704
      23      |       20.218           23                 0.6287
      24      |       20.362           24                 0.6760
      25      |       21.112           25                 0.6864
      26      |       21.381           26                 0.7221
      27      |       23.290           27                 0.6693
      28      |       24.359           28                 0.6624
      29      |       25.322           29                 0.6615
      30      |       27.716           30                 0.5855
      31      |       28.706           31                 0.5846
      32      |       28.728           32                 0.6330
      33      |       29.272           33                 0.6533
      34      |       30.894           34                 0.6207
      35      |       30.897           35                 0.6666
      36      |       33.834           36                 0.5720
      37      |       35.071           37                 0.5597
      38      |       35.519           38                 0.5847
      39      |       38.229           39                 0.5049
      40      |       38.448           40                 0.5402
      41      |       38.548           41                 0.5801
      42      |       39.001           42                 0.6034
      43      |       39.107           43                 0.6408
      44      |       39.122           44                 0.6804
      45      |       39.431           45                 0.7061
      46      |       39.812           46                 0.7278
      47      |       40.011           47                 0.7550
      48      |       40.617           48                 0.7664
-------------------------------------------------------------------------
                        H0: no serial correlation

.
. *5
. reg d.ln_fl_nonfarm l(0/4)d.ln_fl_bp if tin(1948m1,2020m1)

      Source |       SS           df       MS      Number of obs   =       380
-------------+----------------------------------   F(5, 374)       =      2.97
       Model |  .00146591         5  .000293182   Prob > F        =    0.0122
    Residual |  .036972226       374  .000098856   R-squared       =    0.0381
-------------+----------------------------------   Adj R-squared   =    0.0253
       Total |  .038438136       379  .00010142    Root MSE        =    .00994

------------------------------------------------------------------------------
D.           |
ln_fl_nonf~m |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_fl_bp |
         D1. |  -.0043445   .0035864    -1.21   0.227    -.0113965    .0027075
         LD. |  -.0115113   .0040594    -2.84   0.005    -.0194935   -.0035291
        L2D. |   .0019871   .0041056     0.48   0.629    -.0060858      .01006
        L3D. |  -.0011778   .0040768    -0.29   0.773    -.0091941    .0068385
        L4D. |  -.0028262   .0036121    -0.78   0.434    -.0099287    .0042763
             |
       _cons |   .0015358   .0005101     3.01   0.003     .0005328    .0025387
------------------------------------------------------------------------------

. newey d.ln_fl_nonfarm l(0/4)d.ln_fl_bp if tin(1948m1,2020m1), lag(4)

Regression with Newey-West standard errors      Number of obs     =        380
maximum lag: 4                                  F(  5,        374) =      4.01
                                                Prob > F          =     0.0015

------------------------------------------------------------------------------
D.           |             Newey-West
ln_fl_nonf~m |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_fl_bp |
         D1. |  -.0043445    .003622    -1.20   0.231    -.0114665    .0027776
         LD. |  -.0115113   .0036606    -3.14   0.002    -.0187093   -.0043133
        L2D. |   .0019871   .0043475     0.46   0.648    -.0065616    .0105358
        L3D. |  -.0011778    .004813    -0.24   0.807    -.0106416     .008286
        L4D. |  -.0028262    .003664    -0.77   0.441    -.0100308    .0043783
             |
       _cons |   .0015358   .0004154     3.70   0.000     .0007189    .0023526
------------------------------------------------------------------------------

.
. log close
      name:  <unnamed>
       log:  /Users/guslipkin/Documents/Spring2020/CAP 4763 ~ Time Series/Problem S
> ets/Problem Set 2/Problem Set 1.smcl
  log type:  smcl
 closed on:  26 Feb 2021, 18:09:11
-------------------------------------------------------------------------------
```