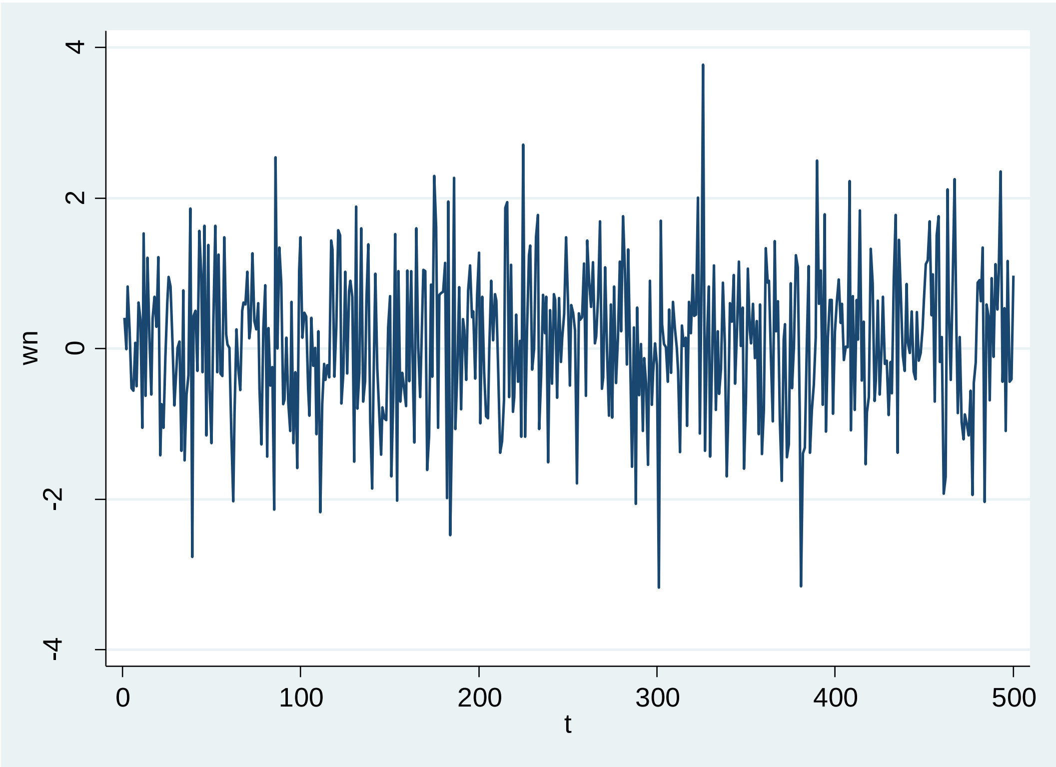
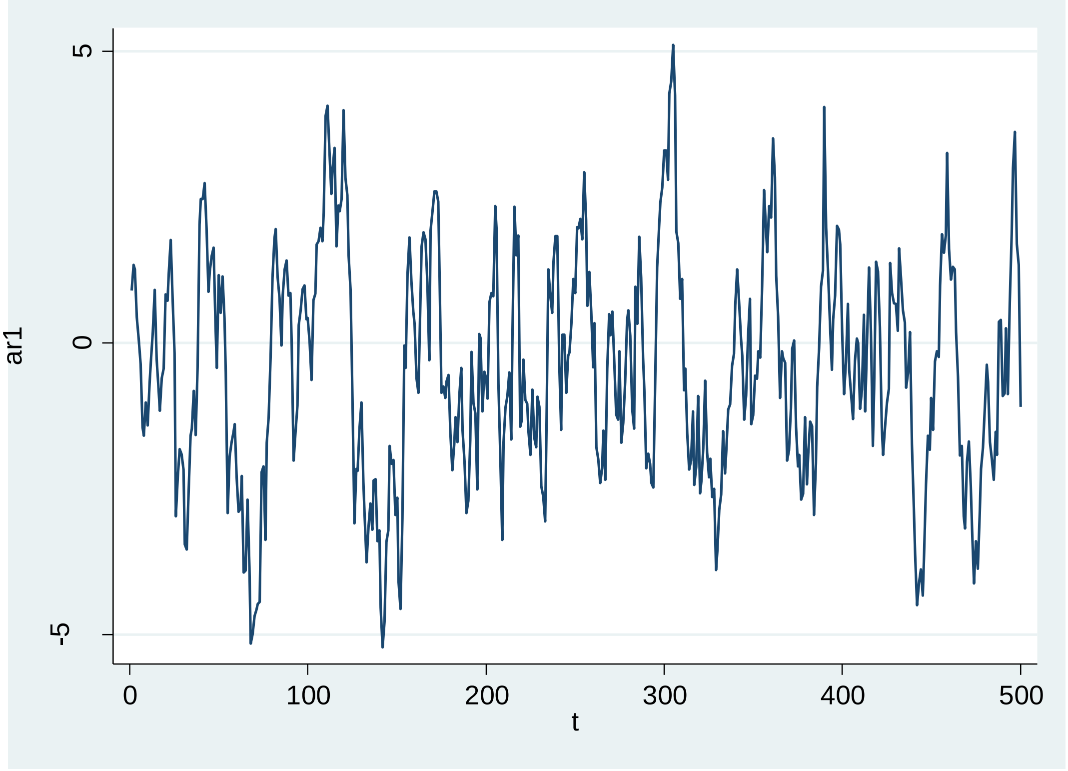
Time Series Models

Simulated AR Time Series

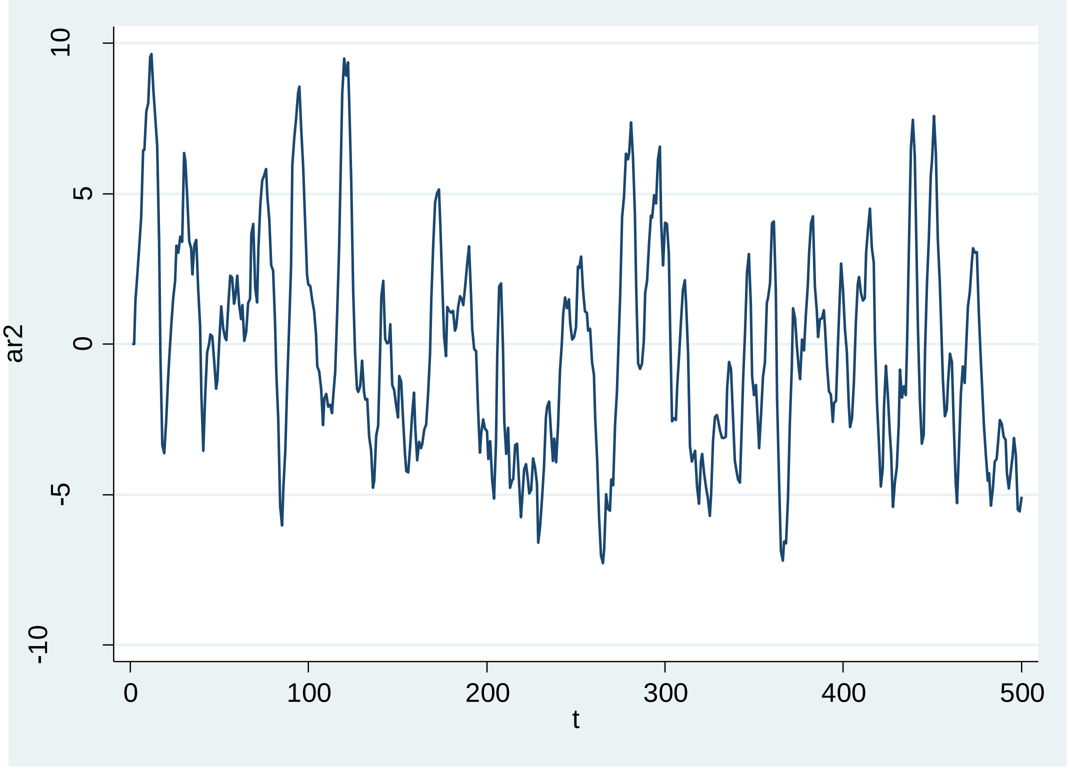
```
. set obs 500
obs was 0, now 500

. g t=_n

. tsset t
        time variable:  t, 1 to 500
                delta:  1 unit

. set seed 1234

. g wn=rnormal(0,1)

. line wn t
```




```
. g ar1=0.9 in 1
(499 missing values generated)

. replace ar1=0.9*l.ar1+rnormal(0,1)if t>1
(499 real changes made)

. line ar1 t
```




```
. g ar2=0 if t<3
(498 missing values generated)

. replace ar2=1.5*l.ar2-0.6*l2.ar2+rnormal(0,1) if t>2
(498 real changes made)

. line ar2 t
```



Random Walk without Drift:

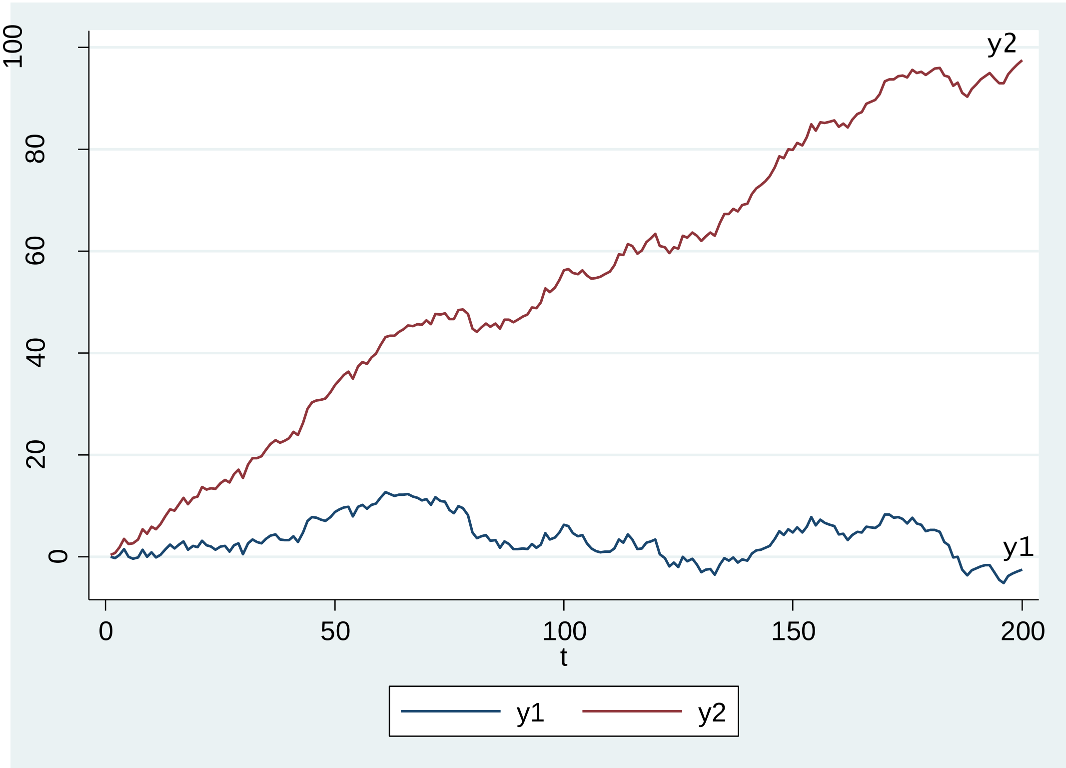
$$Y_{1t} = Y_{1t-1} + u_t$$

where: u_t is white noise error term with mean = 0 and variance = σ^2

Random Walk with Drift:

$$Y_{2t} = \delta + Y_{2t-1} + u_t$$

```
. set obs 200
obs was 0, now 200

. g t=_n

. tsset t
        time variable:  t, 1 to 200
                delta:  1 unit

. set seed 4567

. g u= rnormal(0,1)

. g y1=0 in 1
(199 missing values generated)

. g y2=0.5 in 1
(199 missing values generated)

. replace y1=l.y1 +u if t>1
(199 real changes made)

. replace y2=0.5+l.y2 + u if t>1
(199 real changes made)

. line y1 y2 t
```



Trend Stationary (TS) and Difference Stationary (DS)

Pure random walk $\beta_1 = 0, \beta_2 = 0, \beta_3 = 1$

$$Y_{1t} = Y_{1t-1} + u_t$$

Random walk with drift $\beta_1 \neq 0, \beta_2 = 0, \beta_3 = 1$

$$Y_{2t} = \beta_1 + Y_{2t-1} + u_t$$

Deterministic trend $\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 = 0$

$$Y_{3t} = \beta_1 + \beta_2 t + u_t$$

Random walk with drift and deterministic trend $\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 = 1$

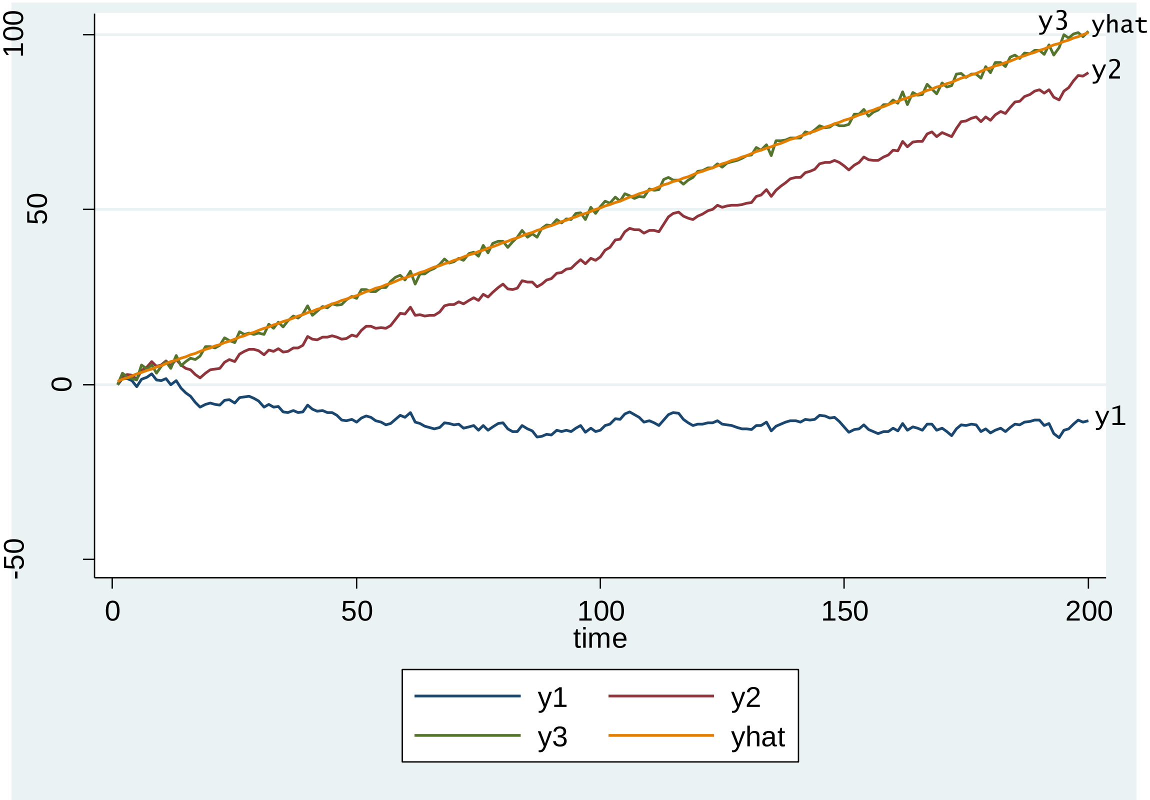
$$Y_{4t} = \beta_1 + \beta_2 t + Y_{4t-1} + u_t$$

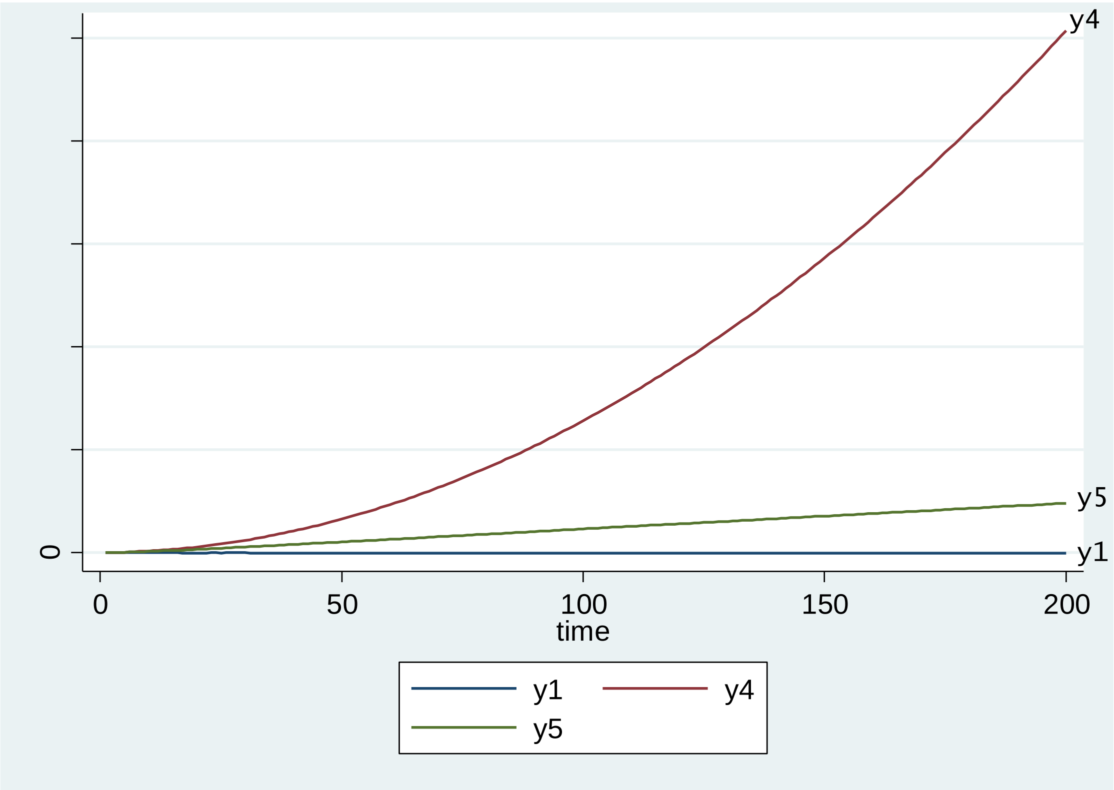
Deterministic trend with stationary AR(1) component $\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 < 1$

$$Y_{5t} = \beta_1 + \beta_2 t + \beta_3 Y_{5t-1} + u_t$$

```
. set obs 200
obs was 0, now 200

. g time=_n

. tsset time
        time variable:  time, 1 to 200
                delta:  1 unit

. g y1=0 in 1
(199 missing values generated)

. g y2=0 in 1
(199 missing values generated)

. g y3=0 in 1
(199 missing values generated)

. g y4=0 in 1
(199 missing values generated)

. g y5=0 in 1
(199 missing values generated)

. set seed 7890

. g u = rnormal(0,1)

. g t=_n

. replace y1=l.y1+u if time>1
(199 real changes made)

. replace y2=0.5+l.y2+u if time>1
(199 real changes made)

. replace y3=0.5+0.5*t+u if time>1
(199 real changes made)

. replace y4=0.5+0.5*t+l.y4+u if time>1
(199 real changes made)

. replace y5=0.5+0.5*t+0.9*l.y5+u if time>1
(199 real changes made)

. g yhat=0.5+0.5*t
```

```
. line y1 y2 y3 yhat time
. line y1 y4 y5 time
```





Unit Root Problem

Autoregressive (Stationary) Series

$$x_{1t} = 0.05 + 0.95\, x_{1t-1} + u_{1t}$$

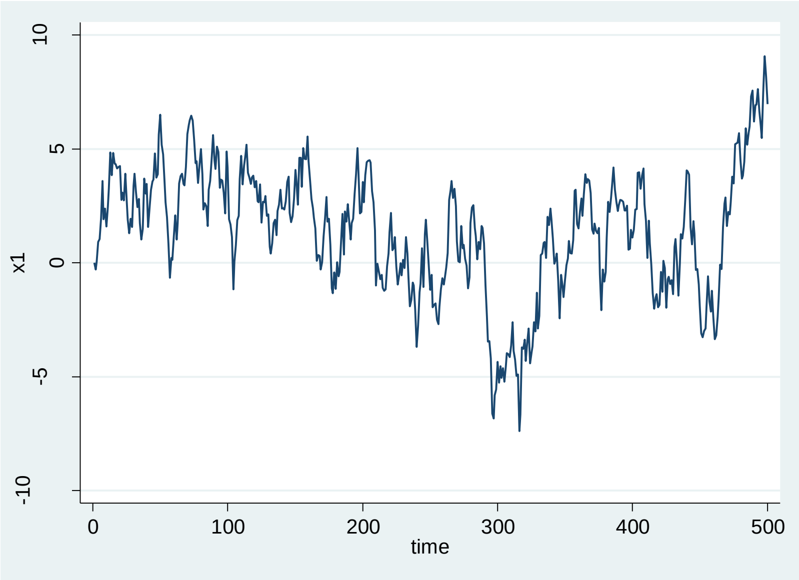
Random Walk with Drift

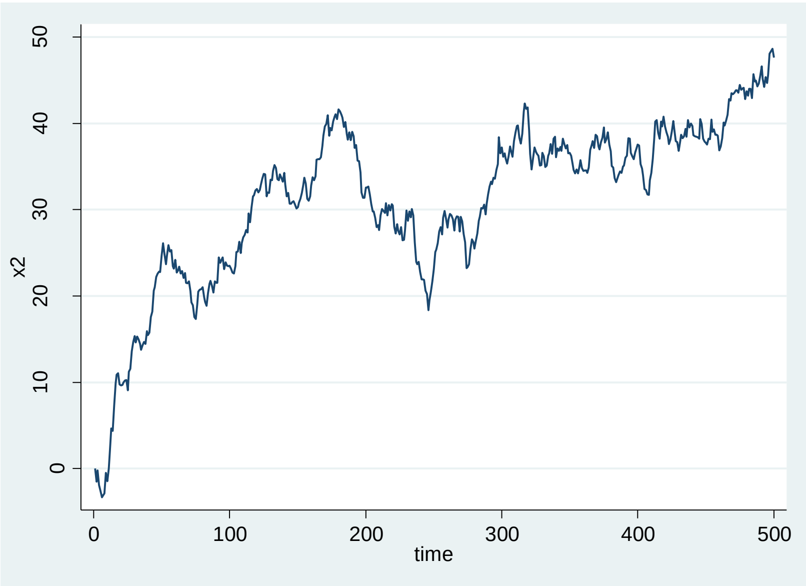
$$x_{2t} = 0.05 + x_{2t-1} + u_{2t}$$

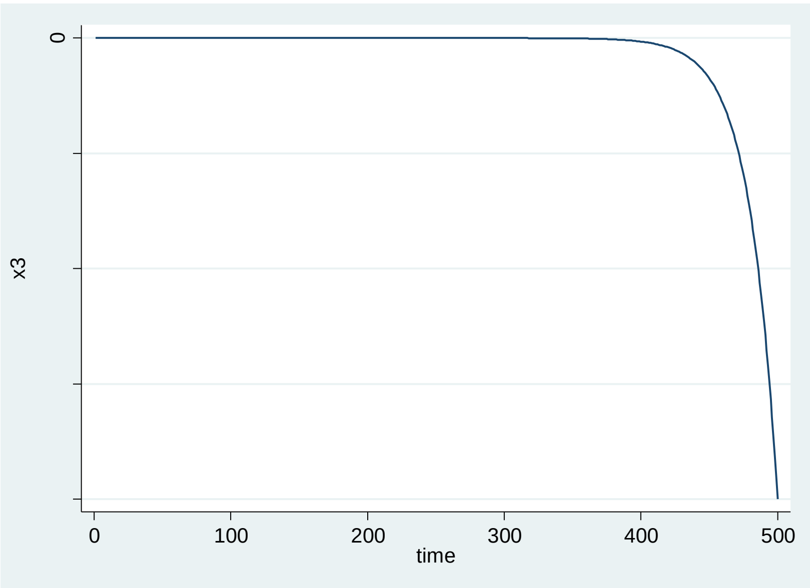
Explosive Series

$$x_{3t} = 0.05 + 1.05\, x_{3t-1} + u_{3t}$$

```
. set obs 500
obs was 0, now 500

. g time=_n

. tsset time
        time variable:  time, 1 to 500
                delta:  1 unit

. g x1=0 in 1
(499 missing values generated)

. g x2=0 in 1
(499 missing values generated)

. g x3=0 in 1
(499 missing values generated)

. set seed 0123

. g u1= rnormal(0,1)

. g u2= rnormal(0,1)

. g u3= rnormal(0,1)

. replace x1=0.05+0.95*l.x1+u1 if time>1
(499 real changes made)

. replace x2=0.05+l.x2+u2 if time>1
(499 real changes made)

. replace x3=0.05+1.05*l.x3+u3 if time>1
(499 real changes made)

. line x1 time

. line x2 time

. line x3 time
```


x1
10
5
0
-5
-10
0
100
200
300
400
500
time


x2
50
40
30
20
10
0
0
100
200
300
400
500
time


x3
0
0
100
200
300
400
500
time

Spurious Regression

$$Y_t = Y_{t-1} + u_t$$
$$X_t = X_{t-1} + v_t$$

If X_t and Y_t are uncorrelated $I(1)$ processes, regression $Y_t = \beta_1 + \beta_2 X_t + \varepsilon_t$ can lead to spurious problem.

```
. set obs 500
obs was 0, now 500

. g time=_n

. tsset time
        time variable:  time, 1 to 500
                delta:  1 unit

. g y=0 in 1
(499 missing values generated)

. g x=0 in 1
(499 missing values generated)

. set seed 5555

. g u= rnormal(0,1)

. g v= rnormal(0,1)

. replace y=l.y+u if time>1
(499 real changes made)

. replace x=l.x+v if time>1
(499 real changes made)

. regress y x

      Source |       SS       df       MS              Number of obs =     500
-------------+------------------------------           F(  1,   498) = 2267.84
       Model |  32835.1366     1  32835.1366           Prob > F      =  0.0000
    Residual |  7210.34126   498  14.4785969           R-squared     =  0.8199
-------------+------------------------------           Adj R-squared =  0.8196
       Total |  40045.4779   499  80.2514587           Root MSE      =  3.8051

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |   -.630954   .0132493   -47.62   0.000    -.6569853   -.6049227
       _cons |   .4784655   .4633948     1.03   0.302    -.4319844    1.388915
------------------------------------------------------------------------------

. dwstat

Durbin-Watson d-statistic(  2,   500) =  .0988012
```

Unit Root Test

```
. set obs 500
obs was 0, now 500

. g t=_n

. tsset t
        time variable:  t, 1 to 500
                delta:  1 unit

. set seed 5432

. g u=rnormal(0,10)

. g y=0 in 1
(499 missing values generated)

. replace y=l.y+u if t>1
(499 real changes made)
```

1. Test with all terms (intercept, trend, and lags):

```
. dfuller y, trend lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.775            -3.980            -3.420            -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7166

------------------------------------------------------------------------------
D.y          |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |  -.0150824   .0084961    -1.78   0.076    -.0317754    .0016106
         LD. |  -.0325012   .0450527    -0.72   0.471    -.1210196    .0560173
      _trend |   .0016688   .0035614     0.47   0.640    -.0053285    .0086662
       _cons |  -.0153098   .9211143    -0.02   0.987    -1.825095    1.794475
------------------------------------------------------------------------------
```

The result shows p-value=0.7166 (fail to reject null hypothesis of unit root). Then, check whether trend is significant and find out that p-value=0.640. Thus, there must be no trend. Go to next step:

2. Test with intercept and lags:

```
. dfuller y,  lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.775            -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3928

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |  -.0131265   .0073943    -1.78   0.076    -.0276546    .0014016
         LD. |   -.033918   .0449156    -0.76   0.451    -.1221668    .0543307
             |
       _cons |   .3511295   .4863518     0.72   0.471    -.6044389    1.306698
------------------------------------------------------------------------------
```

The result shows p-value=0.3928 (fail to reject null hypothesis of unit root). Then, check whether constant term is significant and find out that p-value=0.471. Thus, there must be no constant term. Go to next step:

3. Test with only lags:

```
. dfuller y, nocon lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.623            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |  -.0109853   .0067702    -1.62   0.105     -.024287    .0023165
         LD. |  -.0349845   .0448697    -0.78   0.436    -.1231425    .0531735
------------------------------------------------------------------------------
```

The result shows |Z(t)| = 1.623 is less than |5% Critical Value|=1.950 then fail to reject null hypothesis of unit root. Therefore, the conclusion is there is unit root problem. The series is nonstationary.

```
. dfuller d.y, nocon lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =       497

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -15.366            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
        D2.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         LD. |  -.9954347   .0647826   -15.37   0.000    -1.122717   -.8681519
        LD2. |   -.043815   .0449231    -0.98   0.330    -.1320784    .0444484
------------------------------------------------------------------------------
```

The result shows |Z(t)| = 15.366 is greater than |5% Critical Value|=1.950 then reject null hypothesis of unit root. Therefore, the conclusion is the series is I(1).

Dickey-Fuller GLS Test

```
. dfgls y, maxlag(10)

DF-GLS for y                                             Number of obs =   489

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------
    10           -2.099           -3.480            -2.849            -2.563
    9            -1.839           -3.480            -2.852            -2.567
    8            -1.949           -3.480            -2.856            -2.570
    7            -1.938           -3.480            -2.859            -2.572
    6            -1.828           -3.480            -2.862            -2.575
    5            -1.746           -3.480            -2.865            -2.578
    4            -1.814           -3.480            -2.868            -2.581
    3            -1.732           -3.480            -2.871            -2.583
    2            -1.919           -3.480            -2.874            -2.586
    1            -1.817           -3.480            -2.876            -2.588

Opt Lag (Ng-Perron seq t) = 10 with RMSE  9.753337
Min SC   =  4.618856 at lag  1 with RMSE  9.941964
Min MAIC =  4.607555 at lag  3 with RMSE  9.887703
```

```
. dfgls d.y, maxlag(10)

DF-GLS for D.y                                          Number of obs =   488

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------
    10           -5.103           -3.480            -2.849            -2.564
    9            -5.327           -3.480            -2.852            -2.567
    8            -6.433           -3.480            -2.856            -2.570
    7            -6.491           -3.480            -2.859            -2.572
    6            -6.995           -3.480            -2.862            -2.575
    5            -8.084           -3.480            -2.865            -2.578
    4            -9.441           -3.480            -2.868            -2.581
    3           -10.421           -3.480            -2.871            -2.583
    2           -12.964           -3.480            -2.874            -2.586
    1           -14.522           -3.480            -2.876            -2.588

Opt Lag (Ng-Perron seq t) =  9 with RMSE  9.871131
Min SC   =  4.647202 at lag  1 with RMSE  10.08366
Min MAIC =  5.597676 at lag 10 with RMSE  9.870346
```

Phillips-Perron Test

```
. pperron y, lags(1) regress

Phillips-Perron test for unit root                 Number of obs   =       499
                                                   Newey-West lags =         1

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)           -6.527           -20.499           -14.000           -11.200
 Z(t)             -1.808            -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3765

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |   .9864691   .0073583   134.06   0.000     .9720119    1.000926
             |
       _cons |   .3541393   .4848813     0.73   0.466    -.5985306    1.306809
------------------------------------------------------------------------------

. pperron d.y, lags(1) regress

Phillips-Perron test for unit root                 Number of obs   =       498
                                                   Newey-West lags =         1

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)         -518.457           -20.498           -14.000           -11.200
 Z(t)            -23.193            -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         LD. |  -.0404772   .0448604    -0.90   0.367     -.128617    .0476626
             |
       _cons |   .0048224   .4464789     0.01   0.991    -.8724007    .8820455
------------------------------------------------------------------------------
```

Cointegration Test - Augmented Engle-Granger (AEG) Test

Do file command in generating Cointegrating relationship:

```
set obs 500
g t=_n
tsset t
mat C=(1, 0.7\0.7, 1)
corr2data e1 e2, n(500) mean(0 0) sds(4 5) corr(C)
g x=0 in 1
g y=0 in 1
g dx=0 in 1
g dy=0 in 1
forvalue i=2(1)500 {
  replace dy=0.1+0.2*l.dy+0.3*l.dx-0.5*(l.y-0.1-0.5*l.x)+e1 in `i'
  replace dx=0.2+0.3*l.dy+0.2*l.dx+0.5*(l.y-0.1-0.5*l.x)+e2 in `i'
  replace y=l.y+dy in `i'
  replace x=l.x+dx in `i'
}
```

Unit Root Test to determine Order of Integration of the series

```
. dfuller x, lag(1) trend reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.351            -3.980            -3.420            -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9883

------------------------------------------------------------------------------
D.x          |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |
         L1. |  -.0011524   .0032832    -0.35   0.726    -.0076031    .0052983
         LD. |   .5052605   .0392238    12.88   0.000     .4281944    .5823266
      _trend |   .0021787    .001759     1.24   0.216    -.0012772    .0056347
       _cons |  -.3239806   .5129904    -0.63   0.528    -1.331893    .6839315
------------------------------------------------------------------------------

. dfuller x, lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.593            -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.8725

------------------------------------------------------------------------------
         D.x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |
         L1. |  -.0019149   .0032267    -0.59   0.553    -.0082546    .0044248
         LD. |   .5109265   .0389772    13.11   0.000     .4343453    .5875076
             |
       _cons |   .2299327   .2514875     0.91   0.361    -.2641818    .7240473
------------------------------------------------------------------------------

. dfuller x, nocon lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
```

```
 Z(t)             -0.446            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
         D.x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |
         L1. |  -.0014182   .0031801    -0.45   0.656    -.0076663    .0048299
         LD. |   .5124481   .0389352    13.16   0.000     .4359498    .5889463
------------------------------------------------------------------------------

. dfuller d.x, nocon lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       497

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -10.013            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
        D2.x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |
         LD. |  -.4420748   .0441502   -10.01   0.000    -.5288197     -.35533
        LD2. |  -.1003079   .0445811    -2.25   0.025    -.1878994   -.0127163
------------------------------------------------------------------------------

. dfuller y, lag(1) trend reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.431            -3.980            -3.420            -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9859

------------------------------------------------------------------------------
D.y          |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |  -.0022674   .0052589    -0.43   0.667    -.0125999    .0080651
         LD. |   .2101265   .0443571     4.74   0.000     .1229747    .2972783
      _trend |   .0016933   .0014232     1.19   0.235     -.001103    .0044897
       _cons |  -.2454884   .4159721    -0.59   0.555    -1.062781    .5718044
------------------------------------------------------------------------------

. dfuller y, lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.649            -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.8594

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |  -.0033641   .0051796    -0.65   0.516    -.0135408    .0068127
         LD. |   .2144937   .0442235     4.85   0.000     .1276048    .3013826
             |
       _cons |   .1855889   .2044389     0.91   0.364    -.2160861    .5872639
------------------------------------------------------------------------------

. dfuller y, nocon lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
```

```
               Test         1% Critical       5% Critical      10% Critical
            Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)          -0.499          -2.580            -1.950            -1.620

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |   -.002543   .0050992    -0.50   0.618    -.0125617    .0074756
         LD. |    .215445   .0442032     4.87   0.000     .1285963    .3022936
------------------------------------------------------------------------------
```

```
. dfuller d.y, nocon lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       497

                               ---------- Interpolated Dickey-Fuller ---------
               Test         1% Critical       5% Critical      10% Critical
            Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)         -13.412          -2.580            -1.950            -1.620

------------------------------------------------------------------------------
        D2.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         LD. |  -.7534887   .0561806   -13.41   0.000    -.8638705   -.6431069
        LD2. |  -.0452885   .0447585    -1.01   0.312    -.1332286    .0426516
------------------------------------------------------------------------------
```

Estimate Cointegrating Equation of the series (y and x) using OLS

```
. reg y x

      Source |       SS         df       MS      Number of obs   =       500
-------------+----------------------------------   F(1, 498)       =  65375.48
       Model |  762663.128         1  762663.128   Prob > F        =    0.0000
    Residual |  5809.61273       498   11.665889   R-squared       =    0.9924
-------------+----------------------------------   Adj R-squared   =    0.9924
       Total |  768472.741       499  1540.02553   Root MSE        =    3.4155

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |   .5039868   .0019711   255.69   0.000      .500114    .5078595
       _cons |   .1760628     .15523     1.13   0.257    -.1289236    .4810492
------------------------------------------------------------------------------
```

Predict residual (uhat)

```
. predict uhat, r
```

Perform Unit Root Test: whether uhat is stationary.

```
. dfuller uhat, trend lag(1) reg

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                               ---------- Interpolated Dickey-Fuller ---------
               Test         1% Critical       5% Critical      10% Critical
            Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)         -10.415          -3.980            -3.420            -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.uhat       |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        uhat |
         L1. |  -.4932905   .0473653   -10.41   0.000    -.5863528   -.4002282
         LD. |  -.1214639   .0447212    -2.72   0.007    -.2093312   -.0335966
      _trend |   .0009115    .000955     0.95   0.340    -.0009648    .0027878
       _cons |  -.2308549   .2754893    -0.84   0.402    -.7721301    .3104202
------------------------------------------------------------------------------
```

Estimate Error Correction Mechanism

```
. reg d.y d.x l.uhat

      Source |       SS           df       MS      Number of obs   =       499
-------------+----------------------------------   F(2, 496)       =    335.62
       Model |  6008.99264         2  3004.49632   Prob > F        =    0.0000
    Residual |  4440.26935       496  8.95215595   R-squared       =    0.5751
-------------+----------------------------------   Adj R-squared   =    0.5734
       Total |   10449.262       498  20.9824538   Root MSE        =     2.992

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |
         D1. |   .6287157   .0243408    25.83   0.000     .5808918    .6765395
             |
        uhat |
         L1. |  -.6766761   .0455654   -14.85   0.000    -.7662011   -.587151
             |
       _cons |  -.0517604   .1343186    -0.39   0.700    -.3156641    .2121432
------------------------------------------------------------------------------
```