Assignment 9

```
. dfuller y, trend lag(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)              1.000            -3.980            -3.420           -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 1.0000

------------------------------------------------------------------------------
D.y             |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------+-------------------------------------------------------------
y               |
        L1.     |   .0001178   .0001179     1.00   0.318    -.0001137    .0003494
        LD.     |   .6997015   .0248993    28.10   0.000     .6507799    .7486231
      _trend    |   2.897751   1.159296     2.50   0.013      .619992    5.175511
       _cons    |   1811.233   147.0426    12.32   0.000     1522.327    2100.139
------------------------------------------------------------------------------

. dfuller y, lag(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)             10.999            -3.440            -2.870           -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 1.0000

------------------------------------------------------------------------------
        D.y     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------+-------------------------------------------------------------
y               |
        L1.     |   .0003983   .0000362    11.00   0.000     .0003272    .0004695
        LD.     |   .7218985   .0233849    30.87   0.000     .6759527    .7678444

      _cons     |    1773.23   147.0277    12.06   0.000     1484.355    2062.105
------------------------------------------------------------------------------

. dfuller y, nocon lag(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)              0.347            -2.580            -1.950           -1.620
------------------------------------------------------------------------------

------------------------------------------------------------------------------
        D.y     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------+-------------------------------------------------------------
y               |
        L1.     |   6.29e-06   .0000181     0.35   0.729    -.0000293    .0000419
        LD.     |   .9996004   .0046394   215.46   0.000     .9904852    1.008716
------------------------------------------------------------------------------
```

```
. dfuller x, trend lag(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)             0.601           -3.980            -3.420           -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9970

------------------------------------------------------------------------------
        D.x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
          x |
         L1.|   .0001061   .0001764     0.60   0.548    -.0002405    .0004526
         LD.|     .46018   .0349881    13.15   0.000     .3914361    .5289239
      _trend|   4.166909    1.14105     3.65   0.000     1.924999    6.408818
      _cons|   2128.626   140.0551    15.20   0.000     1853.449    2403.803
------------------------------------------------------------------------------

. dfuller d.x, trend lag(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)           -10.657           -3.980            -3.420           -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
       D2.x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
         D.x|
         L1.|  -.4007114   .0376021   -10.66   0.000    -.4745915   -.3268312
         LD.|   -.414172   .0358603   -11.55   0.000    -.4846298   -.3437141
      _trend|   3.508317   .3506567    10.00   0.000     2.819351    4.197283
      _cons|   1596.429   147.0971    10.85   0.000     1307.415    1885.444
------------------------------------------------------------------------------

. dfuller d.y, trend lag(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)           -10.554           -3.980            -3.420           -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
       D2.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
         D.y|
         L1.|  -.2787856   .0264156   -10.55   0.000    -.3306866   -.2268845
         LD.|   -.32127   .0373756    -8.60   0.000    -.3947051   -.2478349
      _trend|   3.631984   .3708318     9.79   0.000     2.903379     4.36059
      _cons|   1678.082   154.4788    10.86   0.000     1374.564     1981.6
------------------------------------------------------------------------------
```

1. As the p-value is less than 0.05, the null hypothesis of unit root test is failed to reject. Thus, the series are non-stationary. Then, differentiate is suggested to resolve the problem. Therefore, they become stationary.

2.

```
. vecrank y x, trend(t) lag(1/1) max

                    Johansen tests for cointegration
Trend: trend                                         Number of obs =       499
Sample:  2 - 500                                           Lags =          1
------------------------------------------------------------------------------
                                                              5%
maximum                                          trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       4      -7387.4577          .     790.3357    18.17
    1       7      -6992.3441      0.79477     0.1085*    3.74
    2       8      -6992.2899      0.00022
------------------------------------------------------------------------------
                                                              5%
maximum                                          max      critical
  rank    parms       LL       eigenvalue  statistic    value
    0       4      -7387.4577          .     790.2272    16.87
    1       7      -6992.3441      0.79477     0.1085     3.74
    2       8      -6992.2899      0.00022
------------------------------------------------------------------------------

. vecrank y x, trend(rt) lag(1/1) max

                    Johansen tests for cointegration
Trend: rtrend                                        Number of obs =       499
Sample:  2 - 500                                           Lags =          1
------------------------------------------------------------------------------
                                                              5%
maximum                                          trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2      -8050.4781          .    2116.3764    25.32
    1       6      -7075.2453      0.97993    165.9107    12.25
    2       8      -6992.2899      0.28286
------------------------------------------------------------------------------
                                                              5%
maximum                                          max      critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2      -8050.4781          .    1950.4657    18.96
    1       6      -7075.2453      0.97993    165.9107    12.52
    2       8      -6992.2899      0.28286
------------------------------------------------------------------------------

. vecrank y x, trend(c) lag(1/1) max

                    Johansen tests for cointegration
Trend: constant                                      Number of obs =       499
Sample:  2 - 500                                           Lags =          1
------------------------------------------------------------------------------
                                                              5%
maximum                                          trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2      -8050.4781          .    2086.8946    15.41
    1       5      -7083.8611      0.97923    153.6607     3.76
    2       6      -7007.0308      0.26504
------------------------------------------------------------------------------
                                                              5%
maximum                                          max      critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2      -8050.4781          .    1933.2339    14.07
    1       5      -7083.8611      0.97923    153.6607     3.76
    2       6      -7007.0308      0.26504
------------------------------------------------------------------------------
```

```
. vecrank y x, trend(rc) lag(1/1) max

                    Johansen tests for cointegration
Trend: rconstant                                     Number of obs =     499
Sample:  2 - 500                                           Lags =       1
------------------------------------------------------------------------------
                                                              5%
maximum                                            trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       0     -8811.3759          .     3593.1922    19.96
    1       4     -7096.9792      0.99896    164.3988     9.42
    2       6     -7014.7798      0.28069
------------------------------------------------------------------------------
                                                              5%
maximum                                            max      critical
  rank    parms       LL       eigenvalue  statistic    value
    0       0     -8811.3759          .     3428.7934    15.67
    1       4     -7096.9792      0.99896    164.3988     9.24
    2       6     -7014.7798      0.28069
------------------------------------------------------------------------------

. vecrank y x, trend(n) lag(1/1) max

                    Johansen tests for cointegration
Trend: none                                          Number of obs =     499
Sample:  2 - 500                                           Lags =       1
------------------------------------------------------------------------------
                                                              5%
maximum                                            trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       0     -8811.3759          .     3204.1194    12.53
    1       3     -7211.7592      0.99836      4.8860     3.84
    2       4     -7209.3162      0.00974
------------------------------------------------------------------------------
                                                              5%
maximum                                            max      critical
  rank    parms       LL       eigenvalue  statistic    value
    0       0     -8811.3759          .     3199.2334    11.44
    1       3     -7211.7592      0.99836      4.8860     3.84
    2       4     -7209.3162      0.00974
------------------------------------------------------------------------------
```

3.

```
. vecrank y x, trend(t) lag(1) max

                    Johansen tests for cointegration
Trend: trend                                         Number of obs =       499
Sample:  2 - 500                                           Lags =         1
------------------------------------------------------------------------------
                                                              5%
maximum                                            trace      critical
  rank     parms       LL         eigenvalue     statistic      value
    0        4      -7387.4577          .          790.3357     18.17
    1        7      -6992.3441       0.79477         0.1085*     3.74
    2        8      -6992.2899       0.00022
------------------------------------------------------------------------------
                                                              5%
maximum                                            max        critical
  rank     parms       LL         eigenvalue     statistic      value
    0        4      -7387.4577          .          790.2272     16.87
    1        7      -6992.3441       0.79477         0.1085     3.74
    2        8      -6992.2899       0.00022
------------------------------------------------------------------------------

. vecrank y x, trend(t) lag(2) max

                    Johansen tests for cointegration
Trend: trend                                         Number of obs =       498
Sample:  3 - 500                                           Lags =         2
------------------------------------------------------------------------------
                                                              5%
maximum                                            trace      critical
  rank     parms       LL         eigenvalue     statistic      value
    0        8      -6795.5337          .          187.5771     18.17
    1       11      -6703.3826       0.30932         3.2749*     3.74
    2       12      -6701.7451       0.00655
------------------------------------------------------------------------------
                                                              5%
maximum                                            max        critical
  rank     parms       LL         eigenvalue     statistic      value
    0        8      -6795.5337          .          184.3022     16.87
    1       11      -6703.3826       0.30932         3.2749     3.74
    2       12      -6701.7451       0.00655
------------------------------------------------------------------------------

.  vecrank y x, trend(t) lag(3) max

                    Johansen tests for cointegration
Trend: trend                                         Number of obs =       497
Sample:  4 - 500                                           Lags =         3
------------------------------------------------------------------------------
                                                              5%
maximum                                            trace      critical
  rank     parms       LL         eigenvalue     statistic      value
    0       12       -6756.658          .          140.0434     18.17
    1       15       -6688.113       0.24106         2.9534*     3.74
    2       16      -6686.6363       0.00592
------------------------------------------------------------------------------
                                                              5%
maximum                                            max        critical
  rank     parms       LL         eigenvalue     statistic      value
    0       12       -6756.658          .          137.0900     16.87
    1       15       -6688.113       0.24106         2.9534     3.74
    2       16      -6686.6363       0.00592
------------------------------------------------------------------------------
```

4.

```
. vec y x, lag(1)

Vector error-correction model

Sample:  2 - 500                                  Number of obs     =       499
                                                  AIC               =   28.41227
Log likelihood = -7083.861                        HQIC              =   28.42883
Det(Sigma_ml)  =  7.34e+09                        SBIC              =   28.45448

Equation           Parms      RMSE     R-sq      chi2     P>chi2
D_y                    2   331.479   0.9988   399343.6   0.0000
D_x                    2   430.726   0.9953   105050.2   0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_y          |
        _ce1 |
         L1. |  -1.303404   .0095397  -136.63   0.000    -1.322102   -1.284707
             |
       _cons |   -107.843   69.40373    -1.55   0.120    -243.8718    28.18583
-------------+----------------------------------------------------------------
D_x          |
        _ce1 |
         L1. |  -.8364345   .0123959   -67.48   0.000    -.8607301    -.812139
             |
       _cons |   168.0502    90.1839     1.86   0.062    -8.706965    344.8074
------------------------------------------------------------------------------

Cointegrating equations

Equation           Parms      chi2     P>chi2
_ce1                   1   1.71e+10   0.0000

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed

------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
           y |          1          .        .       .            .           .
           x |  -1.500508   .0000115 -1.3e+05   0.000    -1.500531   -1.500486
       _cons |  -1678.204          .        .       .            .           .
------------------------------------------------------------------------------
```

```
. vec y x, lag(2)

Vector error-correction model

Sample:  3 - 500                        Number of obs     =       498
                                        AIC               =  27.18032
Log likelihood = -6758.899              HQIC              =  27.21018
Det(Sigma_ml)  =  2.11e+09              SBIC              =  27.25641

Equation           Parms      RMSE     R-sq      chi2     P>chi2
D_y                    4   213.415   0.9995   964110.3   0.0000
D_x                    4   263.876   0.9982   280728.2   0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_y          |
        _ce1 |
         L1. |   -.427199   .0483639    -8.83   0.000    -.5219905   -.3324075
             |
           y |
         LD. |   .4022605   .0224005    17.96   0.000     .3583563    .4461646
             |
           x |
         LD. |   .4814843   .0598769     8.04   0.000     .3641276    .5988409
             |
       _cons |   171.4547   44.03061     3.89   0.000     85.15624    257.7531
-------------+----------------------------------------------------------------
D_x          |
        _ce1 |
         L1. |   .2903827   .0597995     4.86   0.000     .1731779    .4075875
             |
           y |
         LD. |   .5734396   .0276971    20.70   0.000     .5191544    .6277249
             |
           x |
         LD. |   .3676105   .0740347     4.97   0.000     .2225051    .5127159
             |
       _cons |    252.237   54.44157     4.63   0.000     145.5335    358.9405
------------------------------------------------------------------------------

Cointegrating equations

Equation           Parms      chi2     P>chi2
_ce1                   1  8.09e+08     0.0000

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed

------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
           y |          1          .        .       .            .           .
           x |  -1.500176   .0000527 -2.8e+04   0.000    -1.50028   -1.500073
       _cons |  -577.9622          .        .       .            .           .
------------------------------------------------------------------------------
```

5.

```
. vec y x, lag(3)

Vector error-correction model

Sample:  4 - 500                                  Number of obs     =       497
                                                  AIC               =   27.1245
Log likelihood = -6727.439                        HQIC              =  27.16771
Det(Sigma_ml)  =  1.96e+09                        SBIC              =  27.23459

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
D_y                    6   211.673   0.9995   980003.4   0.0000
D_x                    6   253.098   0.9984   305162.2   0.0000
------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_y          |
        _ce1 |
         L1. |  -.3193909    .058155    -5.49   0.000    -.4333726   -.2054092
             |
           y |
         LD. |   .3553209   .0559202     6.35   0.000     .2457194    .4649225
        L2D. |   .0174858   .0312998     0.56   0.576    -.0438607    .0788323
             |
           x |
         LD. |   .6042668   .0763396     7.92   0.000     .4546439    .7538896
        L2D. |   .0521968   .0634683     0.82   0.411    -.0721988    .1765925
             |
       _cons |   181.5838   45.38519     4.00   0.000     92.63049    270.5372
-------------+----------------------------------------------------------------
D_x          |
        _ce1 |
         L1. |   .4434064   .0695359     6.38   0.000     .3071185    .5796943
             |
           y |
         LD. |   .4713427   .0668638     7.05   0.000     .3402922    .6023932
        L2D. |    .012763   .0374252     0.34   0.733     -.060589    .0861151
             |
           x |
         LD. |   .5220109   .0912792     5.72   0.000     .3431069     .700915
        L2D. |   .0911602   .0758891     1.20   0.230    -.0575797    .2399001
             |
       _cons |    130.797   54.26707     2.41   0.016     24.43548    237.1585
------------------------------------------------------------------------------

Cointegrating equations

Equation           Parms      chi2     P>chi2
------------------------------------------------------------------
_ce1                   1  6.64e+08     0.0000
------------------------------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed

------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
           y |          1          .       .       .            .           .
           x |  -1.500049   .0000582 -2.6e+04   0.000    -1.500163   -1.499935
       _cons |  -92.13439          .       .       .            .           .
------------------------------------------------------------------------------
```

Lag 3 is the most appropriate for VECM model due to the lowest value determined by SBIC. The cointegrate equation is y-1.5x-92.13439=0. Then, rearrange to be y=92.13439+1.5x. the speed of adjustment parameter of y is -0.319 and x is 0.443.